$$(13)\qquad T\log p = 5.409\,(t-100) - 0.508\times 10^{-8} \times \left\{(365-t)^4 - 265^4\right\}$$

in which t is measured from 0° C.

This equation, which only contains two constants to be determined from the observations of vapor tension, represents the best observations between 0° C. and 180° C. quite well; from it there follows:

$$\frac{d\log p}{dT} = 0.07268 \text{ at } 0°\text{ C.}$$

Hence we obtain by our second method the value:

$$\frac{\sigma_0}{R T_0^2} = \frac{79.9}{596.3}\times 0.07268 = 0.00974$$

The perfect agreement of this second with the preceding value demonstrates the applicability of the Avogadro law at 0° C. and makes quite probable the assumption of the applicability of Marriott's law, which was assumed in deducing equation (5).

The still remaining value of ρ' in equation (8) is the sum of ρ and σ for 0° C. and is equal to 676.2. Its variation with temperature at 0° C. is equal to $-0.545 + 0.526 = -0.019$ for each degree centigrade and can be neglected in the present problem. This is materially smaller than the change of the density of ice with temperature; a still greater constancy [in the change of ρ' with temperature] results from the agreement of the values of the specific heat of ice and vapor as observed by Regnault.

If now we sum up all our results we find that the equation of condition (8) takes such a form that t is a quantity that depends on quantities that vary slowly with t. Therefore we easily find for t an approximate value, and after computing for this approximate value the slowly varying quantities, we find the exact value of t. The execution of this computation gives the following:

$$(14)\qquad -t = \frac{\log\frac{676.2}{602.7}}{0.00975\times 1.005} = 11.7°.$$

Consequently the extrapolation of the quantities that enter into the computation extends to a few degrees only, and the computed value can be considered as quite certain. Fischer, in his observations, had already come so near to this temperature[4] that he certainly would, at lower temperatures, have observed no appreciably greater difference between the tension of saturated vapor over ice and over water.

We now proceed to the attempt to compute the tensions themselves and first the tension of vapor over ice. From equation (6) by integration, considering the above found approximate constancy of ρ' as being perfect, there results

$$(15)\qquad \log\frac{p'}{p_0} = \frac{\rho'}{R T_0}\,\frac{t}{T},$$

and if we substitute the above found value and pass to common logarithms, we obtain

$$(16)\qquad \operatorname{Log}\frac{p'}{p_0} = 9.78\,\frac{t}{T}.$$

The value of Log p_0 resulting from equation (13) is —2.2198, or + 0.6610 in case we adopt a millimeter of mercury as the unit of pressure. With this value, the values of p', given in the table below have been computed by the use of equation (16).

In the computation of the vapor tension over water the value of ρ given by equation (12) is to be substituted in equation (5) in order to be consistent with the assumptions of this present article. The result of the integration of the equation thus obtained can be expressed in definite form, but a development in series is preferable. For high temperatures the result will then certainly be incorrect, since the law of Marriott then no longer obtains; but for very low temperatures this is of no importance, since at these temperatures it is no longer possible to keep the water in its fluid condition; therefore we give the development that form which seems most appropriate for temperatures in the neighborhood of 0° C., viz:

$$(17)\ \log\frac{p}{p_0} = \frac{\rho_0}{R T_0}\cdot\frac{t}{T}\left(1 - \frac{t}{6(\tau - T_0)} + \frac{3\tau - 5T_0}{18\,T_0(\tau-T_0)^2}t^2 - \ldots\right)$$

or after the substitution of the numerical values:

$$(18)\qquad \operatorname{Log}\frac{p}{p_0} = \frac{t}{T}\left(8.628 - 0.00394\,t + 0.000002\,t^2 - \ldots.\right).$$

The values of p given below have been computed by this formula.

As above stated the empirical formula (13) represents the observations of vapor tension at the higher temperatures very well. But it would appear *a priori* improper to apply it to very low temperatures, since this formula does not harmonize well with the assumption of the applicability of the Marriott law. It is therefore necessary to investigate to what extent the continuity is practically preserved in the computation of p by the two formulæ (13) and (18). We therefore rewrite equation (13) in the same form as equation (18) and it becomes:

$$(19)\qquad \operatorname{Log}\frac{p}{p_0} = \frac{t}{T}\left(8.617 - 0.00406\,t + 0.000007\,t^2 \ldots\right).$$

The difference between the values of p computed by formulæ (19) and (18) attains a maximum of about 0.0016^{mm} of mercury in the neighborhood of $t = -13.6°$ C. Therefore, in consideration of the accuracy of our present knowledge of the observed vapor tensions, we may consider formulæ (18) and (19) as identical for temperatures below 0° C.

Of all the assumptions that underlie the computation of the values of p and p' in the following table, that of the vapor tension at 0° C. is the most uncertain. However, even a perfectly accurate new determination for the lower temperatures would scarcely give anything more than an improvement on this value, but it would of course be more desirable to determine it directly. The values of p' for very low temperatures are of interest in questions of cosmic physics.

Pressures of saturated aqueous vapor expressed in millimeters of mercury.

t.	Over ice. p'.	Over water. p.
°C.	*Mm.*	*Mm.*
0	4.581	4.581
— 5	3.010	3.162
—10	1.946	2.145
—11.7	1.672	1.873
—15	1.237	1.432
—20	0.772	0.939
—25	0.473	0.604
—30	0.284	.....
—35	0.167	.....
—40	0.096	....
—45	0.054	.....
—50	0.029	.....
—55	0.016	.....
—60	0.008	....
—65	0.004	....
—70	0.002	.....
—75	0.0009	.....
—80	0.0004	.....

AURORAL OBSERVATIONS ON THE SECOND WELLMANN EXPEDITION MADE IN THE NEIGHBORHOOD OF FRANZ JOSEF LAND.

By EVELYN B. BALDWIN, Observer, Weather Bureau.

A very complete record of auroral phenomena was kept by

[4] W. Fischer, Wiedemann's Annalen, 1886, Vol. XXVIII, p. 400.

Mr. E. B. Baldwin as the meteorologist of the second Wellmann Expedition, in connection with his detailed meteorological record. The latter was published as Part VII of the Annual Report of the Chief of the Weather Bureau for 1899–1900. It is understood that the hours and minutes in this record refer to local mean time.

The record itself is as follows:

AT FORT MCKINLEY.

October 7, 1898, 7:45 *p. m.*—Aurora visible in the east first as a faint band of light, brightening into a waving curtain or curtains, extending from a point in the southwest to far into the northeast. From 10 p. m. of the 7th to 2:30 a. m. of the 8th display very bright and beautiful. At 10 p. m. beams of light shot upward, converging in the vicinity of Cassiopeia. Pressure, 30.13 to 30.14; temperature, 12° to 9° F.; wind, northeast at 8 miles per hour.

October 21, 1898, 7 *p. m.*—Aurora, curtain form, in the zenith. Pressure, 29.70; temperature, —1° F; wind, northwest at 12 miles per hour.

ON A SLEDGE JOURNEY.

October 22, 1898, 6 *p. m.*—Aurora, curtain form, in the zenith. Pressure, 29.96; temperature, —11°; wind, north at 10 miles per hour.

October 25, 1898, 5 *p. m.*—Aurora, curtain form and fine, east to west across the zenith. Pressure, 29.89; temperature, 12° F; wind, calm.

October 27, 1898, 4 *p. m.*—Aurora, a faint streak in the zenith, extending from east to west. Pressure, 30.05; temperature, —4° F.; wind, north, light.

AT HARMSWORTH HOUSE, FRANZ JOSEF LAND, 80° N.; 58° E. NOVEMBER 1, 1898, TO MARCH 13, 1899.

November 1, 1898, 12 *noon.*—Light auroral streaks, extending east and west, from Cassiopeia across Ursa Major. Pressure, 30.23; temperatures, —11° F.; wind, north at 34 miles per hour.

November 3, 1898, 6 *p. m.*—Aurora, light parallel rays in two bands extending east and west through Ursa Major over Polaris and terminating in Cepheus. Pressure, 30.40; temperature, —5° F.; wind, north at 14 miles per hour.

9 *p. m.*—Aurora, a faint patch of auroral rays over the head of Taurus, being brightest in the vicinity of Aldebaran. Pressure, 30.38; temperature, —5.5° F.; wind, north at 15 miles per hour.

November 4, 1898, 8 *p. m.*—Aurora, a light or yellowish band upon the rump of Ursa Major and a similar phenomenon just below Aldebaran, or Alpha Tauri. Pressure, 30.30; temperature, —9° F.; wind, north at 15 miles per hour.

10 *p. m.*—Aurora, two light parallel bands from Taurus to Pegasus. Pressure, 30.30; temperature, —9.0° F.; wind, north at 16 miles.

November 5, 1898, 8 *p. m.*—Aurora, two light parallel bands extending from the head of Taurus (brightest in the vicinity of Aldebaran) just below Cassiopeia, and terminating immediately below the head of Draco. Pressure, 30.25; temperature, —10.0° F.; wind, northeast at 8 miles per hour.

10 *p. m.*—Aurora, a fine display of yellowish light bands and curtains extending from Taurus in the east, across the head of Cetus, the lower member of Pisces, Aquarius, and Capricornus. Pressure, 30.25; temperature, —10.0° F.; wind, north at 8 miles per hour.

November 6, 1898, 10 *p. m.*—Aurora, a grand display under all the circumpolar constellations within 35° of Polaris. Form variable, in bands, curtains, patches, and rays; color, yellowish; movement, northwest to south or southeast. Pressure, 30.23; temperature, —6.0° F.; wind, south, light.

November 7, 1898, 4 *p. m.*—Aurora, three nearly parallel bands from east to west, or from Cassiopeia across the neck of Camelopardus and the body of Ursa Major to the body of Leo. Aurora and stars visible through alto-cumulus clouds. Pressure, 29.95; temperature, 6.0° F.; wind, north at 10 miles per hour.

6:20 *p. m.*—Aurora, continuation of the above display as four waving curtains of light yellowish hue, following, in a general way, the zodiacal constellations Aries, Cetus, Pisces, Pegasus, Aquila, Aquarius, and Capricornus. Meteor descended from east to west. Pressure, 30.00; temperature, 0° F.; wind, north at 10 miles per hour.

November 7, 1898, 9:10 *p. m.*—Continuation of the above auroral display, including the constellations Gemini, Taurus, and Ophiuchus. Pressure, 30.05; temperature, —4.0° F.; wind, north at 10 miles per hour.

9:20 *p. m.*—Very beautiful display, extending over all circumpolar constellations. Form, folding curtains, inclining toward Gamma Cephei (knee of Cepheus). Color, light yellow generally, but at times showing the colors of the spectrum and occasionally of uniform reddish-yellow as portions of the curtains changed to cloud-like forms. Motion through every point of the compass, but wave movement generally from east to west and from west to east, the curtains moving en masse from south to north or vice versa. Display remarkably bright at times, casting sufficient light to give the appearance of moonlight upon the snow, and strong enough to cast shadows of the limbs of the observer. Pressure, 30.05; temperature, —5.0° F.; wind, north at 10 miles per hour.

10 *p. m.*—Gradual diminution of the display till its final cessation about 10:30 p. m. Pressure, 30.05; temperature, —6.0° F.; wind, northwest at 10 miles per hour.

November 8, 1898, 3:55 *p. m.*—Aurora, a light yellowish bow extending from Aries, in the east, across the head of Taurus, and across the bodies of Camelopardus, Lynx, and Ursa Major, terminating on the bodies of Leo Minor and Leo Major and ascending from Ursa Major, as a bright yellow curtain (tinted with the colors of the rainbow), the beams or rays of light inclining toward a point midway between Polaris and the head of Draco, that is toward the body of Draco and the knee of Cepheus (see also auroral display 9:20 p. m. of yesterday). Meteor shot across the body of Leo Minor, from north to south. Pressure, 30.22, temperature,—12.0° F.; wind, northeast, light.

8:45 *p. m.*—Continuation of the display through varying phases to its appearance at this period as an irregularly shaped bow, between Aries and Taurus, in the east, below Pegasus, over the body of Aquarius, between Aquila and Capricornus, across Ophiuchus and Serpens, Libra and Virgo. Sky overcast, but the bow plainly indicated in subdued yellow. Wind, light from the north. Pressure, 30.20; temperature, —13.5° F.; wind, north, light.

November 9, 1898, 12:50 *a. m.*—Aurora, a yellow patch or cloudlike form over the body of Pegasus. Pressure, 30.18; temperature, —14.0° F.; wind, north, light.

2 *p. m.*—Aurora, display began at 2 p. m. as a luminous patch nearly in the zenith, and at 3:45 p. m. gradually assumed the form of an irregularly shaped yellowish bow extending from east to west across Cetus, Pisces, head of Pegasus, Equuleus and Aquarius, head of Ophiuchus, Serpens and Hercules, Corona Borealis, Bootes, Canes Venatici, and Coma Berenices, the phenomenon at 4 p. m. being a series of long and short bows covering, in a general way, the circumpolar constellations. Meteor, describing a short path from northeast to southwest across the body of Leo Minor, was observed at 3.45 p. m. Gradual appearance or growth of bows from south to north, but movement from north to south. Pressure, 30.05; temperature, —15.0° F.; wind, northeast, light.

5.55 *p. m.*—Continuation as a great luminous canopy, elliptical in contour, extending in a northeast and southwest direc-

tion. Folding curtain hanging from edges of canopy and rapid movement of curtain in opposite directions, that is, in a general way; east curtain moving eastward and the west curtain moving westward, thus extending the canopy to axes of from 15° (northwest and southwest) to 45° (northeast and southwest) from the zenith. Portion of curtain hanging in the northeast being of a greenish color. Pressure, 30.05; temperature, —16.0° F.; wind, northeast and nearly calm.

8 *p. m.*—Continuation of the display as in the previous paragraph, with the addition of a bow from 5° to 10° northward of the central luminous canopy. In general, the display permanent from Orion and Taurus in the east to Libra and Virgo in the west. The curtains inclining sharply and distinctly toward Cepheus, converging or knotting in that constellation. Rapid movements in the bow and canopy from west to east, alternating irregularly with turbulent motion in the canopy, as in snow driven about by violent gusts of wind. Occasional appearances of shafts, rays or beams of yellowish light, separate from the curtains, but parallel with the planes or faces of the same, and therefore pointing toward Cepheus. Pressure, 30.04; temperature, —17.0° F.; wind, northeast, light.

November 10, 1898, 5:20 *p. m.*—Aurora, a light yellowish semibow extending from the rump of Leo Major, in the west, across Coma Berenices, Canes Venatici and the tail of Ursa Major to Cepheus. Pressure, 30.05; temperature, —18.0° F.; wind, north at 18 miles.

7:45 *p. m.*—Continuation of the display as a field of light or thin canopy covering the constellations immediately surrounding Polaris, with curtains hanging from the edges of the canopy, the brightest curtain on the north edge, extending from Taurus in the east, the feet of Auriga the bodies of Lynx and Leo Minor, Coma Berenices, the tail of Ursa Major and Canes Venatici, and terminating in the west, upon the breast of Bootes. Pressure, 30.06; temperature, —17° F.; wind, northeast at 18 miles per hour.

9:48 *p. m.*—Continuation of the display as a light yellowish patch, covering the head of Orion and the horns of Taurus and springing thence as a tenuous bow across Perseus, Cassiopeia, Cepheus, Draco, and Hercules. Pressure, 30.06; temperature, —17.0° F.; wind, northeast at 18 miles per hour.

November 11, 1898, 5 *p. m.*—Aurora, a yellowish bow extending from Taurus in the east-northeast across Triangulum, Andromeda, Cygnus, Lyra, the heads of Hercules, Ophiuchus and Serpens, and terminating in the west southwest in the region of Virgo. Pressure, 30.19; —19.3° F.; wind, northeast at 19 miles per hour.

7 to 8.30 *p. m.*—Continuation of the display as a double arc or bow extending from Orion in the east, the fore limbs of Taurus, bodies of Aries, Pegasus, Vulpecula, heads of Hercules, Ophiuchus, and Serpens and terminating in the region of Virgo, the northernmost bow is the brighter. A light series of "patches" extending from the fore limbs of Taurus across the head of Cetus, the lower member of Pisces, Aquarius, Capricornus, the lower limbs of Ophiuchus, Libra, and terminating upon the skirt of Virgo. Pressure, 30.20; temperature, —20.0° F.; wind, northeast at 19 miles per hour.

November 12, 1898, 6 *a. m.*—Aurora, a light bow springing from Orion and extending thence irregularly toward Cepheus. Pressure, 30.23; temperature, —19.0° F.; wind, northeast at 19 miles per hour.

9 *a. m.*—Aurora, an arch or bow of yellowish light, extending from Orion in the west, and crossing Canis Minor, Cancer, the head of Hydra, Leo Major, Canes Venatici, the tail of Ursa Major, and resting upon Draco. Pressure, 30.25; temperature, —18.5°; wind from the northeast at 18 miles per hour.

5 *p. m.*—Aurora, a double arch springing from Cetus, the lower and brighter bow passing thence over Pegasus, Aquarius, Capricornus, the lower limbs of Ophiuchus, Libra, Virgo, and terminating upon Coma Berenices in the west; the upper bow covering Pegasus Vulpecula, Hercules, Corona Borealis, Bootes, and meeting the lower bow upon Coma Berenices. Pressure, 30.40; temperature, —18.0° F.; wind, northeast at 17 miles per hour.

6:30 *p. m.*—Continuation of the display as a light "patch" over Orion and the fore limbs of Taurus, with beams ascending thence to Cassiopeia and Cepheus. Pressure, 30.44; temperature, —18.5° F.; wind, northeast at 17 miles per hour.

9 *p. m.*—Continuation of the display as a golden bow, partially obscured by thick weather, extending from Orion in the east and thence following the constellations of the celestial equator to Bootes in the west, also two bands or series of parallel beams, the one extending from Coma Berenices, across the breast of Bootes and the body of Draco, to the lower limbs of Cepheus, the other from Vulpecula, across the neck and northern wing of Cygnus to the lower limbs of Cepheus (the two bands thus forming an acute angle upon the lower limbs of Cepheus). Pressure, 30.49; temperature, —18.5° F.; wind, northeast at 17 miles per hour.

November 13, 1899, 4 *p. m.*—Aurora, light beams ascending from Coma Berenices across Canes Venatici, the tail of Ursa Major, and body of Draco. Pressure, 30.74; temperature, —20.0° F.; wind, northeast at 8 miles per hour.

5 *p. m.*—Aurora, a golden bow extending from the head of Cetus across lower Pisces, the back of Pegasus, Aquarius, Capricornus, the lower limbs of Ophiuchus, Libra, Virgo, and Leo Major, with beams ascending from the portion of the bow covering Leo Major and Virgo, across Canes Venatici, Coma Berenices, Bootes, tail of Ursa Major, bodies of Draco and Ursa Minor to Cephus. Pressure, 30.74; temperature, —21.0° F.; wind, northeast at 8 miles per hour.

8 *p. m.*—Continuation of the display; beams or shafts of yellowish light ascending from Orion and Taurus and crossing Perseus and the feet of Cassiopeia and meeting upon Cepheus, similar shafts ascending, firstly, from Corona Borealis and Hercules, and crossing the body of Draco, and, secondly, from Aquila, crossing Vulpecula and Lyra. Pressure, 30.70; temperature, —20.5° F.; wind, northeast at 8 miles per hour.

November 16, 1898, 5 *p. m.*—Aurora, a light arch (golden), brightest at the beginning or origin, springing from the head of Cetus, crossing the lower member of Pisces, Aquarius, Capricornus, Ophiuchus, and Libra, and terminating in the vicinity of Libra. Very light arc extending from Corona Borealis across the feet of Hercules, the body of Draco and Cepheus to Cassiopeia. Meteor, originating in Cassiopeia, descended 10° toward southeast. Pressure, 30.00; temperature, 27.5° F.; wind, east, very light.

November 17, 1898, 5 *a. m.*—Aurora, arch. Pressure, 28.55; temperature, 26.5° F.; calm.

9 *p. m.*—Aurora, a golden glow, producing a striking effect upon the edges of a long, black-looking stratus cloud in the south, i. e., the aurora behind the cloud, thus giving the cloud a golden "lining" from the belt of Orion in the east across the head of Cetus, lower member of Pisces, and terminating upon the breast of Aquarius, with beams passing thence upward across the heads of Aquarius and Pegasus to the body of Cepheus. Pressure, 28.61; temperature, 18.0° F.; wind, west, light.

10:30 *p. m.*—Continuation of the display as an irregular bow covering the above-mentioned constellations. Meteor descended southeast from Cassiopeia. Pressure, 28.61; temperature, 14.5 F.; wind, west, light.

11:30 *p. m. to* 12:30 *a. m.*—Same as at 10:30 p. m., with increase in light and number of arcs or broken bows from the tail of Ursa Major to Cassiopeia. Noticeable moonshine

effect directly traceable to the display, varying with intensity of display and clearly casting a shadow of the observer. Pressure, 28.61; temperature, 14.0° F.; wind, west, light.

November 18, 1898, 12:35 *p. m.*—Aurora, a shaft of light ascending from Canis Minor in the west-northwest. Pressure, 28.65; temperature, —5.0° F.; wind, northwest at 16 miles per hour.

1 *p. m.*—Continuation of display, arcs and beams ascending from Aquarius in the east across the head and neck of Pegasus, Equuleus, Delphinus, Vulpecula, and neck of Cygnus to Cepheus. Pressure, 28.65; temperature, —5.0° F.; wind, northwest at 16 miles per hour; dip circle, 82.0; azimuth, oscillating, eastern declination, increased.

3:45 *p. m.*—Continuation of display; bright golden glow around dark stratus clouds above eastern, southern, and western horizon, the glow being very bright upon belly and fore limbs of Pegasus, lower member of Pisces, breast of Aquarius and back of Capricornus, and reflected upon alto-cumulus clouds, extending from edge of stratus clouds to zenith. Alto-cumulus clouds moving from northwest and stratus clouds from southwest. Wind from northwest and gusty, blowing fine, wet snow. Pressure, 28.65; temperature, 6.0° F.; wind, northwest at 16 miles per hour.

5 *p. m.*—Dip circle, normal, 82° 30′; reading, 82° 30′; azimuth circle, normal, 151° 40′, with slight oscillation of needle; aurora, bright oval-shaped field of light springing from Orion and head of Cetus, in the east, across Taurus, Aries, Perseus, Andromeda, Camelopardus, Cassiopeia, Cepheus, Ursa Minor (including Polaris), Draco, tail of Ursa Major, and Bootes. Pressure, 28.65; temperature, 6.0° F.; wind, northwest at 18.5 miles per hour.

8 *p. m.*—Dip circle, normal, 82° 00′; reading, 82° 30′; azimuth circle, normal, 151° 40′; first reading, 153° 25′; second reading, 152° 05′; declination increased at first reading (circle increasing from left to right); no oscillation observable.

Aurora, bright display in west, with light glow in east, drifting snow, and dark stratus clouds preventing exact location of display, referred to constellations or stars. Pressure, 28.68; temperature, 8.0° F.; wind, northwest at 20 miles per hour.

November 19, 1898, 5 *p. m.*—Aurora, light yellow bow extending from Taurus and Cetus, in the east, across Perseus, Cassiopeia, Cepheus, Ursa Minor, tails of Draco and Ursa Major to Bootes, in the west, with yellowish streamers and diffused light arising from Leo Major, in the north, crossing Leo Minor, head and shoulders of Ursa Major, and apparently inclined toward Polaris and Cepheus. Pressure, 29.19; temperature, 3.0° F.; wind, northwest at 12 miles per hour.

5:40 *p. m.*—Continuation of display with yellow band extending along eastern horizon from Orion to shoulder of Taurus and head of Cetus, rising thence as diverging bows or semicircles of gold, inclining from Polaris 45° southward and converging upon Bootes. Pressure, 29.16; temperature, 2.5° F.; wind, northwest at 10 miles per hour.

7 *p. m.*—Aurora, continuation of display as series of incomplete and complete bows rising from Orion and Taurus, in the east, and covering space thence northward to Polaris and descending to Bootes; also continuous bow springing from head of Cetus, crossing Pegasus, Aquila, heads of Ophiuchus and Hercules, and uniting with the other bow upon Bootes. Bows crossed transversely by lower stratus clouds, thus concealing sections of bows. Movements of eastern arcs from south to north, with streamers or rays converging thence toward Polaris and Cepheus. Arcs of bows at highest altitude, shading from violet or lilac on northern edges to green. Pressure, 29.18; temperature, 2.0° F.; wind, southeast, nearly calm.

Dip circle: 82° 30′ (normal). Azimuth circle: 152° 20′ and no oscillations of needle observable.

7:40 *p. m.*—Display continues as about described in preceding paragraph, with increased movement of eastern arcs toward the north (geographical). Meteor descends midway between Ras Alhague and Ras Algethic, disappearing upon the left shoulder of Ophiuchus. Pressure, 29.19; temperature, 0.0°; wind, calm.

8:30 *p. m.*—Continuation, with increase of light in west, movement of arcs in that region from north to south. Streamers from all parts of display converging toward and upon Cepheus. Black spots upon eastern arcs having appearance of clouds, but in reality being blue sky appearing black by contrast; stars scintillating brightly in these black spaces, and light, or edges of arcs surrounding them, expanding till the identity of clear sky is revealed. Traces of green and red observable. Movement of eastern arcs from south to north as a whole, with shuttle-like motion from east to west, or vice versa in individual arcs, with occasional rapid springing of portions of the arcs in opposite directions from given points in the same arc at the same moment. Pressure, 29.20; temperature, —1.0° F.; wind, southeast, very light.

11:45 *p. m.*—Continuation of the display from Orion, across Cetus, Aquarius, and Capricornus to the breast of Ophiuchus. Dark stratus clouds breaking the bow. Pressure, 29.20; temperature, —2.0° F.; wind, southeast, very light.

November 21, 1898, 4 *p. m.*—Aurora, yellow cloud-like forms in the south.

4:45 *p. m.*—Continuation of the display as a waving curtain from Gemini in the north, across Lynx and Camelopardus, meeting an arc or curtain ascending from Taurus across Perseus, feet of Cassiopeia and Cephus, Polaris, and tail of Ursa Major. Pressure, 29.62; temperature, —1.0° F.; wind, north at 7.5 miles per hour.

5 *p. m.*—Dip circle: Oscillating between 82° 30′ (normal) and 83° 00′ for twenty minutes. Azimuth circle: oscillating for twenty minutes. First reading, 158° 28′; second reading, 156° 05′ (normal 151° 50′). Continuation of auroral display; bright yellow arc or three-quarters of a circle resting upon Auriga, Camelopardus, and Lynx, brightest portion upon Camelopardus, with opening in opposite direction, toward Gemini, and great spiral tongue shading into tints of green, red, and blue, curving from Auriga around upon Perseus, Cassiopeia, Cepheus, Draco, Ursa Minor, Ursa Major, and Bootes, followed by wide expansion of arc and tongue into great arc or bow extending from east to west through zenith with alto-stratus clouds crossing and veiling sections of same in west; bow accompanied by short arcs, rays, and masses of yellow on both sides, while beams of silvery yellow shot upward converging upon Cepheus and Cassiopeia, the display then gathering great intensity with a storm of yellow surging upon Cepheus, during which time oscillations of dip and azimuth needles were greatest. Pressure, 29.62; temperature, —1.0° F.; wind, north at 7.5 miles per hour.

9 *p. m.*—Display continues as an acute angle of light yellow streaks extending from Orion in the east-southeast across the head of Cetus, Pegasus, and Aquarius, meeting similar streak upon Aquila, this streak or band extending thence across Cygnus and Cepheus to Cassiopeia. Pressure, 29.63; temperature, —1.0°; wind, north at 7.5 miles per hour.

9:30 *p. m.*—Corona Borealis in northwest flaming in yellow tinged with green, violet, and blue. Pressure, 29.63; temperature, —1.0° F.; wind, north at 7.5 miles per hour.

November 22, 1898, 3:30 *a. m.*—Aurora, yellow plane 10° in width, streaked with stratus clouds extending across Canis Minor, head of Monoceros, Orion, head of Cetus, lower member of Pisces, back of Pegasus, head of Aquarius, and Aquila, with bow of silvery yellow beams springing from region of Monoceros, crossing Canis Minor, Gemini, Cancer, Lynx, head of Ursa Major, tail of Draco, body of Ursa Minor, and rest-

ing upon the head of Draco. Pressure, 29.63; temperature, —6.0° F.; wind, northeast at 12 miles per hour.

2 *p. m.*—Aurora, a waving curtain of yellow tinted with green and lilac, extending from Aquila, Vulpecula, Cygnus, head of Draco and Bootes. Pressure, 29.60; temperature, —13.5° F.; wind, northeast at 20 miles per hour.

November 23, 1898, 5 *p. m.*—Aurora, a double arc of silver from the head of Cetus in the east, across Pegasus, Cygnus, Vulpecula, Lynx, Hercules, Corona Borealis, and Bootes, with silvery cloud-like forms scattered generally over the heavens. Moon shining brightly. Pressure, 29.63; temperature, —11.0° F.; wind, northeast 29.7 miles per hour.

November 24, 1898, 11 *p. m.*—Aurora, a light shaft (of beams) ascending 10° from the feet of Gemini. Weather fine; bright moonshine through the clouds. Pressure, 29.70; temperature, 2.0° F.; wind, northwest at 11.5 miles per hour.

November 27, 1898, 3:30 *to* 4:30 *p. m.*—Aurora, light beams playing upward from Bootes (in the west), Leo Major, Leo Minor, Cancer, Gemini, and Auriga. Pressure, 29.85; temperature, —8.0 to 9.5 F.; wind, northeast, light.

3:30 *to* 9:30 *p. m.*—Aurora, a beautiful display in the form of beams and brilliantly colored curtains darting and moving from Leo Major in the northeast, across Canis Minor, Orion, head of Cetus, lower member of Pisces, Aquarius, Capricornus, and Aquila. At 9:30 p. m. the dip circle oscillating between 85° (normal) and 84° 30′. Bright moonshine. Pressure 29.84; temperature, —12.0° to —15.0° F.; wind, northeast, light.

November 28, 1898, 9 *p. m.*—Aurora, a very brilliant display of curtain form, first from Orion in the east-southeast, across the head of Cetus, lower member of Pisces, Aquarius, Capricornus, rising higher and playing rapidly among the stars of Aquila, Cygnus, Pegasus, and Cepheus, forming at length a whirlpool of green, purple, and lilac with beams and curtain planes converging upon Cepheus, at which moment the azimuth circle moved quickly from its normal position at 14° 40′ (reset), to 17° 40′. The general movement of the entire display was from east to west, at 9:30 p. m., a curtain of color extending from Bootes in the north across Ursa Major, Lynx, and Leo Major. Pressure, 29.90; temperature, —17.0° F.; wind, northeast, light.

November 29, 1898, 4 *p. m.*—Aurora, faint yellowish beams displaying from Cancer, Virgo, and Bootes, becoming a bright combination of green and lilac in the vicinity of Virgo. Pressure, 29.87; temperature, —18.0 F.; wind, northeast at 10 miles per hour.

December 2, 1898, 10 *p. m.*—Aurora, a light arc hanging from Cassiopeia. Pressure, 29.87; temperature, —16.0° F.; wind, northeast at 6 miles per hour.

December 4, 1898, 5 *p. m.*—Aurora, a bright golden double arc from Taurus and Cetus in the east-southeast across Pegasus and the lower member of Pisces, Equuleus, Vulpecula, the heads of Ophiuchus and Serpens, Hercules, and Corona Borealis to Bootes. Pressure, 30.10; temperature, —10.0° F.; wind, northeast at 32 miles per hour.

10 *p. m.*—Continuation of above display. Pressure, 30.12; temperature, —11.0° F.; wind, northeast at 30 miles per hour.

December 7, 1898, 11 *a. m.*—Aurora, a bright double bow of gold, varying in form to that of curtains extending from Taurus and Cetus, in the northeast, across Andromeda, Cassiopeia, Cepheus, Ursa Minor, and rump of Ursa Major, to Leo Major, on the one hand, and from same initial point across Andromeda and belly of Pegasus, Cygnus, and Draco to Bootes. Display continued during p. m., streaks of stratus clouds crossing same at lower elevation. Pressure, 30.45; temperature, —9.0° F.; wind, north at 26 miles per hour.

5 *p. m.*—Aurora, continuation of the display as an arc of yellowish light extending from Bootes across Corona Borealis, Hercules, and Draco to Cepheus. Pressure, 30.44; temperature, —11.2° F.; wind, north at 14 miles per hour.

9:30 *p. m.*—Aurora, golden figures, in shape resembling the comma and interrogation mark, extending from Bootes, in the north, across the tail and rump of Ursa Major, the tail of Draco, Ursa Minor, and the lower limbs of Cepheus, to Cassiopeia. Pressure, 30.29; temperature, —3.0° F.; wind, northeast at 6 miles per hour.

December 8, 1898, 11 *a. m.*—Aurora, golden glows crossed by narrow bands of stratus clouds from the head of Cetus, in the northeast, across Aries, shoulders and neck of Taurus (Pleiades visible through the same) and terminating upon the lower limbs of Auriga. Pressure, 30.27; temperature, —4.8° F.; wind, southwest at 9 miles per hour.

5 *p. m.*—Aurora, a very light arc extending from Leo Major, in the east, across Auriga, Ursa Major, Coma Berenices, and Canes Venatici to Bootes. Pressure, 30.26; temperature, —13.5° F.; wind, west-northwest at 6 miles per hour.

9:30 *p. m.*—Aurora, continuation of the forenoon display as a bright golden semicircle extending from Sextans and the fore paws of Leo Major across the head of Hydra, Monoceros, Canis Minor, the belt of Orion, Cetus, Aquarius, and Capricornus. Pressure, 30.25; temperature, —21.0° F.; wind, north at 10 miles per hour.

10 *to* 10:30 *p. m.*—Grandest display of the season, nearly the entire northern heavens being resplendent in green and red purple beautifully intermingled with waving curtains of gold, graceful arcs of silver, and darting, dancing, leaping, falling shafts of fire the entire phenomenon forming at 10 p. m. a vast corona seemingly supported upon pillars of fire converging upon the region between Cassiopeia and the lower limbs of Cepheus, at which moment there was rapid oscillation of the azimuth needle and pendulum-like motion of the dip circle needle between 85° 00′ (normal) and 84° 30′. Pressure 30.25 to 30.26; temperature, —22.0° F.; wind, north at 10 miles per hour.

December 9, 1898, 3 *p. m.*—Aurora, a light band extending from Taurus (covering the Pleiades) in the east, across Andromeda, Cassiopeia, Cepheus, Draco, Ursa Minor, tail and rump of Ursa Major, Canes Venatici, and terminating upon Bootes. Pressure, 30.28; temperature, —28.0° F.; wind, northeast at 8 miles an hour.

4 *p. m.*—Continuation of the display as a bright silver-yellow double arc covering the preceding constellations with maximum brightness over Cepheus and Draco. Arcs swinging gradually from north to south and vice versa. Pressure, 30.29; temperature, —28.0° F.; wind, northeast at 8 miles per hour.

5 *p. m.*—Afternoon auroral display alternately appearing and vanishing, gradually reappearing at 5 p. m. as two golden fields, the one in the east covering the head of Cetus, slowly rising thence across the Bee, Triangulum, Aries, the upper member of Pisces, Andromeda, and Cassiopeia, and meeting upon Cepheus; the other emerging from the head of Serpens, in the west, and crossing thence Hercules and Draco. Pressure, 30.28; temperature, —28.0° F.; wind, northeast at 5.8 miles per hour.

10 *p. m.*—Continuation of the auroral display as a flaming cone of yellow with the apex upon Cepheus and the base extending from Leo Major, in the east, across the feet of Gemini, heads of Orion, Taurus, and Cetus to Aquarius; then gradually crumbling into a field of delicate blue-green and again changing to a waving curtain, now folding itself rapidly to the east and then as rapidly to the west. Pressure, 30.30; temperature, —24.0° F.; wind, northeast at 9 miles per hour.

December 10, 1898, 3 *to* 5 *p. m.*—Aurora, continuation of the display, appearing as a faint light in the northwest at 3 p. m., but at 5 p. m. existing as a pale green arc curtain-shaped for 10° above the horizon at the east and west points, with a spray or mist-like roll intervening, the entire bow springing from

the shoulders of Orion (in the east), curving sharply upon the head of Taurus (place of greatest intensity with curtain of red-green color) and thence over Perseus, Cassiopeia, Cepheus, Ursa Minor, the main part of the body of Draco and Hercules to the head of Serpens. Pressure, 30.42; temperature, —23.0° F.; wind, northeast at 11.5 miles per hour.

10 *p. m.*—Aurora, a dull green arc extending from Leo Major and Sextans, in the northeast, across the head of Hydra, the lower claw of Cancer, Canis Minor, feet of Gemini, head of Taurus, lower member of Pisces, and resting upon the back of Pegasus. Pressure, 30.45; temperature, —24.0°; wind, northeast at 8.4 miles per hour.

December 11, 1898, 3 *to* 7:30 *p. m.*—Aurora began at 3:00 p. m. as a light green arc extending from Leo Major in the northeast across the constellation thence to Ursa Major and gradually expanding into a collection of small arcs and luminous spaces covering Cepheus, Cassiopeia, and Cygnus. At 5 p. m. the display was marked by reddish-green shafts inclining from the constellations in the east and west, toward Cepheus. At 7:30 p. m. a silvery green bow, folded in places into a curtain form, marked its course from the paws of Leo Major upon the head of Hydra, lower claw of Cancer, feet of Gemini, head of Orion, Taurus, Aries, Pisces, and Pegasus. Pressure, 30.66 to 30.70; temperature, —28.0° F. to —29.0° F.; wind, south, very light.

10 *p. m.*—Aurora, covering the constellations as at 7:30 p. m., of the curtain variety and of beautiful red-green color. Parts of the curtain waving in opposite directions (to the east and to the west) from given points. Occasionally meteors of short paths ascending toward Aries from the head of Taurus. Pressure, 30.70; temperature, —27.0° F.; wind, southwest, very light.

December 12, 1898, 5 *p. m.*—Aurora, a dim yellow band in the north and northwest, much obscured by drifting snow, covering Leo Major, Cancer, the feet of Gemini, the lower limbs of Taurus, and the head of Cetus. Pressure, 30.75; temperature, 4.8° F.; wind, northwest at 20 miles per hour.

December 14, 1898, 5 *p. m.*—A dull yellow arc (much obscured by clouds) extending from Taurus, in the east, crossing Aries, the lower member of Pisces, Aquarius, and Capricornus. Pressure, 30.50; temperature, —6.0° F.; wind, northeast at 10 miles per hour.

December 15, 1898, 3 *to* 5 *p. m.*—Aurora, a dull yellow arc (began at 3 p. m.) from Taurus, in the east, extending over Aries and the lower member of Pisces to Aquarius. Pressure, 30.55; temperature, —8.0° F.; wind, north at 18 miles per hour.

10 *to* 11.30 *p. m.*—Continuation of the display; one brightly colored arc in the east, seeming to extend from north to south, with a curvature or bend toward the west, covering the paws of Leo Major, Cancer, the feet of Gemini, Canis Minor, and the right shoulder of Orion; in reality, only one of a series of arcs and bows covering the constellations and parts of constellations of the celestial equator and ecliptic, viz, Taurus, Aries, Cetus, the lower member of Pisces, Aquarius, and Capricornus; all of the arcs brightly tinted in green and blue and red, with silvery rays stringing the stars upward half way to the zenith and of unusually low elevation above the sea level, the entire phenomenon displaying singular absence of motion (was this owing to great humidity of the air?). Pressure, 30.57 to 30.58; temperature, —6.5° F.; wind, north at 18 miles per hour.

December 16, 1898, 11 *a. m.*—Aurora, very light beams and rays in the north playing upon Gemini, Auriga, and the head of Taurus. Pressure, 30.60; temperature, —10.2° F.; wind, north at 24 miles per hour.

12 *noon.*—Bright patch covering the rump of Ursa Major, with beams playing thence and from Coma Berenices across Draco and Ursa Minor, and an arc crossing Cancer and the feet of Gemini, in the northeast. Pressure, 30.60; temperature, —11.0° F.; wind, north at 24 miles per hour.

5 *p. m.*—Aurora, continuation of the day's display as a bright silvery arc covering Canis Minor, the head of Monoceros, the upper portion of Orion, Taurus, Cetus, Aries, the lower member of Pisces, the back of Pegasus and Aquarius, with thin sheets of rays scattered here and there to a second arc extending from Auriga across Lynx, the belly and legs of Ursa Major, Leo Minor, Canes Venatici and Coma Berenices to Bootes, the arcs changing to curtain forms tinted in green and red and waving from west to east, with the rays converging or inclining toward the zenith. Pressure, 30.62; temperature, —10.0° F.; wind, northeast at 17 miles per hour.

December 17, 1898, 3 *to* 9:30 *p. m.*—Aurora, a bright silver-yellow double curtain accompanied by ascending beams extending from the fore limbs of Taurus across the head of Cetus, Aries, Pegasus, and Aquila to the heads of Ophiuchus and Hercules. Display began at 3 p. m. as a series of beams ascending from Coma Berenices, in the northwest, passing thence through varying phases to the form observed at 5 p. m., at which time waving folds rapidly moved from east to west and vice versa (alternating), deeply tinged with red-green color, brightest in the region of the head of Cetus. 9:30 p. m., a whirlpool of light (beams, swaying curtains, broken arches, globular patches) covering the head of Leo Major, Leo Minor, Ursa Major, Draco, Ursa Minor, the lower limbs of Cepheus, Cassiopeia, Camelopardus, Lynx, Cancer, Gemini, Canis Minor, the head of Monoceros, the head and breast of Orion, Auriga, Taurus, the head of Cetus, Aries, Perseus, Andromeda, and Pegasus, the brightest portion tinged with green and red, undulating rapidly from southwest to northeast, from Pegasus across Cassiopeia to Leo Major, and swirling about with great rapidity in the region of Cepheus, a restless canopy of color in mid-air throwing its light upon the earth as from the full moon on a clear night. Pressure, 30.45; temperature, —16.0° F.; wind, northeast at 13 miles per hour.

December 18, 1898, 2:30 *to* 5 *p. m.*—Aurora, began at 2:30 p. m. as light beams ascending from Leo Major, Cancer, and Gemini. Pressure, 30.35; temperature, —22.0° F.; wind, northeast at 21.5 miles per hour.

December 19, 1898, 2 *p. m.*—Aurora, a bright golden sheet beautifully tinted in green and red arching from the head of Cetus in the east, crossing Auriga, Camelopardus, and Lynx, to Leo Major and Leo Minor in the west. Pressure, 30.25; temperature, —14.5° F.; wind, northeast at 25 miles per hour.

8 *to* 9 *p. m.*—Continuation of the aurora; two writhing serpents of light, extending from the east to the west, and covering the stars and constellations as follows: The first, and brightest, with its head upon Regulus, crossing thence Cancer and the head of Gemini (Castor and Pollux) Lynx, the head of Ursa Major, the tail of Draco to the body of Hercules; the second, much more tenuous in appearance, springing from the shoulders of Orion, and crossing the feet of Auriga, Perseus, Camelopardus, Ursa Minor, and Draco, and finally blending with the termination of the first upon the body of Hercules. 9 p. m., a continuous arc, brightly colored in green and red in places, extending from the Leos in the north-northeast, across the lower claw of Cancer, the head of Hydra, Canis Minor, and the body of Monoceros, to the breast of Cetus. Pressure, 30.14; temperature, —17.0° F.; wind, northeast at 9 miles per hour.

December 20, 1898, 2 *a. m.*—Aurora, yellowish streaks crossed by stratus clouds in Orion and vicinity. Pressure, 29.99; temperature, —15.0° F.; wind, northeast at 9 miles per hour.

2 *to* 9:30 *p. m.*—Aurora, began at 2 p. m. as slightly colored arcs of reddish yellow, covering Taurus in the northeast and Virgo and Coma Berenices in the west; at 5 p. m. a series of

alternating yellow arcs and silvery veils tinged with red and green, extending from Taurus in the east, across Auriga, Camelopardus, the knees of Cepheus, Ursa Minor, Draco, and Hercules to Ophiuchus in the west. 9:30 p. m., bright golden arc extending from Canes Venatici, across the head of Draco, and between Hercules and Lyra to Aquila. Pressure, 30.72 to 30.70; temperature, —21.0° F.; wind, northwest at 9.5 miles per hour.

December 21, 1898, 5 *p. m.*—Aurora, a silvery band crossing Auriga, Lynx, and Leo Minor, all in the north. Pressure, 30.64; temperature, —25° F.; wind, northwest, very light.

7:15 *to* 10 *p. m.*—A golden band and arch streaked and spotted with stratus clouds to a distance of one-fourth of its length, beginning at Leo Major in the northeast, passing thence across the lower claw of Cancer, the feet of Gemini, Canis Minor, the head and shoulders of Orion, the head of Taurus, and ascending thence across Auriga, Camelopardus, Cassiopeia, and Cepheus, descending upon Cygnus and Vulpecula to Aquila. 10 p. m., silvery yellow arcs swinging above dark stratus clouds, but below alto-stratus clouds in the west. Display carefully observed and relation to the clouds strikingly apparent. Pressure, 30.65; temperature, —27° F.; wind, northwest, very light.

December 22, 1898, 11 *a. m.*—Aurora, light streamers ascending from Aries (tinted here in red and green and playing vigorously), the head of Taurus, Auriga, and Gemini, all above the northern horizon. Pressure, 29.66; temperature, —24.5° F.; wind, west-northwest, very light.

5 *p. m.*—Aurora, a silvery yellow arc above the northern horizon covering the feet of Gemini, Cancer, and the shoulders of Leo Major. Pressure, 30.60; temperature, —22° F.; wind, northwest at 7 miles per hour.

December 28, 1898, 2 *p. m.*—Aurora, bright silvery-golden arcs and streamers tinted here and there with green and red, covering the head of Cetus in the east, Aries, Andromeda, Cassiopeia, Cepheus, Ursa Minor, the main body of Draco, and Bootes in the west, arcs swaying from south to north; the surface wind from the northeast; arcs and streamers appearing to meet upon or incline toward Cepheus. Pressure, 29.35; temperature, —30° F; wind, north, very light.

December 29, 1898, 5 *to* 9 *p. m.*—Aurora, a light golden arch extending from Gemini in the east across Auriga, Cassiopeia, Cepheus, body and head of Draco, to Lyra in the southwest. 7:30 p. m., golden bow reaching from shoulders of Orion in the southeast across Taurus, Aries, Pisces, and Pegasus. Wind from the west, light. Bright meteor visible two seconds, descending (approaching observer like head light of locomotive) from Gamma Geminorum. 9 p. m., visible beneath alto-stratus clouds covering three-tenths of the sky in the southeast. Pressure, 29.77 to 30.08; temperature, —15° to —22° F.; wind, northwest at 8 miles per hour.

December 30, 1898, 5 *p. m.*—Aurora, a light silvery arch from the shoulders of Orion in the southeast across Taurus, Aries, Pisces, belly of Pegasus, and Vulpecula to head of Ophiuchus, and Hercules. 9 p. m., continuation as an irregular golden sheet covering Pegasus (in south-southwest), Vulpecula, Lyra, Hercules, and lower limbs of Bootes in the north. Pressure, 29.57; temperature, —35° F.; wind, northeast, light.

December 31, 1898, 9:30 *p. m.*—Aurora, a light arc crossing the chest of Orion (in the southeast), Cetus and Aquarius (in the west), simultaneous with a display of red-green streamers ascending from Vulpecula, Cygnus, Lyra, Hercules, Corona Borealis, Bootes, Coma Berenices, and the Leos. Pressure, 29.98; temperature, —32° F.; wind, north at 8 miles per hour.

January 1, 1899, 11 *a. m.*—Aurora, light silvery streamers tinged with green ascending from Cetus (in the northeast), Taurus, and Auriga (in the north). Pressure, 30:32; temperature —34.4° F.; wind, southwest at 10.6 miles per hour.

January 3, 1899, 2 *p. m.*—Aurora, streamers ascending from Taurus (in the northeast), the head of Auriga, Camelopardus, Ursa Major, Bootes, and the main body of Draco, and inclining toward Cepheus. Pressure, 29.93; temperature, —20.0° F.; wind, northeast at 12.3 miles per hour.

5 *to* 10 *p. m.*—Aurora, yellowish arcs, crossing Taurus, in the southeast, also rising from Gemini and Cancer, in the east, crossing Lynx, Ursa Major, Draco, Ursa Minor, and Cygnus. 10 p. m., continuation as a yellow band springing from the limbs of Leo Major (in the northeast), crossing Sextans, the head of Hydra, Canis Minor, the belt of Orion (clearly visible in the south, with Rigel sparkling like a diamond), the head of Cetus, and the lower member of Pisces. First time since the stars became visible this season (1898–99) that they have twinkled or sparkled with intensity, doubtless owing, on this occasion, to lack of humidity in the upper air currents. No clouds visible at 10 p. m. Pressure, 30.00 to 30.10; temperature, —7.0° F. to —14.0° F.; wind, north at 14.3 miles per hour.

January 4, 1899, 9:30 *to* 11 *a. m.*—Aurora, streamers ascending from Aries and Taurus (in the north); at 10 a. m. extending across Gemini; at 11 a. m. rising only from the feet of Gemini. Pressure, 30.22 to 30.25; temperature, —14.5° F. to —16.0° F.; wind, northeast at 9.3 miles per hour.

2 *to* 5 *p. m.*—Aurora, bright streamers ascending from Taurus (in the northeast), Gemini, Cancer (in the north), the Leos, Ursa Major, and Bootes (in the west), and inclining toward and upon Cepheus and Ursa Minor. 4 p. m., a bright double curtain of gold with changing tints of rose, lilac, and purple, screened or draped in a veil of silvery gauze, extending from Orion (in the east-northeast) across the head of Taurus, Aries, the upper member of Pisces, the belly of Pegasus, Vulpecula, Cygnus, Lyra, and Hercules. 5 p. m., a golden band extending from Canis Minor (in the northeast) across the head of Orion (in the east), and thence nearly through the zenith to the position of Hercules, in the west; appearing in spaces between clouds—stratus and stratus-cumulus. Pressure, 30.29 to 30.33; temperature, —18.0° F. to —20.0° F.; wind northeast, at 8 miles per hour.

January 5, 1899, 9:30 *to* 11 *a. m.*—Aurora, light streamers ascending from Taurus (in the north) Gemini, and Cancer. 10 a. m., light streamers ascending from Aries. 11 a. m., continuation. Pressure, 30.58 to 30.61; temperature, —20.5° to —23.0° F.; wind, northeast, light to calm.

5 *to* 10 *p. m.*—Aurora, bright arcs and arches extending from Orion and Canis Minor, in the east, across the horns of Taurus, Gemini, Cancer, Leo Major, Auriga, Lynx, Leo Minor, Ursa Major, Ursa Minor, Cepheus, and Draco to Hercules and Corona Borealis, in the west. 10 p. m., continuation. Pressure, 30.63 to 30.60; temperature, —9.5° to —17.0° F.; wind, southwest, light.

January 7, 1899, 5 *p. m.*—Aurora, bright streamers in the west ascending from Corona Borealis and the upper portion of the body of Bootes, crossed by narrow bands of stratus clouds beneath. Pressure, 30.50; temperature, —13.0° F.; wind, northwest at 12 miles.

January 9, 1899, 5 *p. m.*—Aurora, a light golden band from Canis Minor, in the east-northeast, crossing the lower claw of Cancer, the upper portion of Leo Major (in the north), and Coma Berenices, with light streamers ascending from Bootes, Corona Borealis, and Hercules. Pressure, 20.23; temperature, —13.0° F.; wind, northeast at 8 miles per hour.

January 10, 1899, 9:45 *p. m.*—Aurora, a golden arc springing from Cancer (in the east), and crossing Gemini and Taurus (in the south). Pressure, 30.10; temperature, —18.0° F.; wind, northeast at 20 miles per hour.

January 11, 1899, 2 *to* 11 *p. m.*—Aurora, light streamers ascending from Leo Major (in the north-northwest) and Coma Berenices at 2 p. m.; bright golden arcs tinged with red, rising

from the shoulders of Orion (in the east), crossing Auriga, Camelopardus, Ursa Minor, Draco, and Hercules at 4 p. m.; the same much increased in intensity and number of arcs and expanse of celestial dome covered, at 5 p. m. to 10 p. m., continuation. Pressure, 30.07 to 30.09; temperature, —10.0° to —4.0° F.; wind, northeast at 15 miles per hour.

January 14, 1899, 5 *p. m.*—Aurora, a bright arc in the south. Pressure, 30.21; temperature, —19.0° F.; wind, northeast at 27.3 miles per hour.

January 15, 1899, 2 *to* 5 *p. m.*—Aurora, bright golden arcs, arches, and spots, crossing the entire celestial dome from east to west. Visible also at 2 p. m. Lunar halo in the southwest. Pressure, 30.12 to 30.08; temperature, —26.0° F; wind, north at 30 miles per hour.

9 *p. m.*—Aurora, bright golden arc crossing belt of Orion (in the south) and other constellations of celestial equator. (No pressure, temperature, or wind, entered in connection with this aurora).

January 17, 1899, 5 *to* 10 *p. m.*—Aurora, bright golden arches, extending from Orion and Gemini, in the east, across Auriga, Lynx, Ursa Major, and the upper portion of Bootes to Hercules, in the west. At 7 p. m., a great, writhing, serpent of gold, tinted reddish-green in places, extending from Coma Berenices at the head and chest of Virgo, in the north, across the limbs of Leo Major, Cancer, Gemini, Auriga, Perseus, Andromeda, the body of Pegasus, and Vulpecula, to the heads of Hercules and Ophiuchus, in the west, with lighter gauze like arches crossing Taurus, Aries, the head of Cetus, Aquarius, and Capricornus. 8 p. m. Continuation, the display being especially bright in the regions of Leo Major and the belt of Orion. 5 to 10 p. m. Display continuing through varying phases. Pressure, 29.90 to 29.97; temperature, —26.5° to —33.0° F.; wind, north at 16.7 miles per hour.

January 18, 1899, 1 *to* 7:45 *p. m.*—Aurora, began at 1 p. m. as a light arch extending from Ophiuchus and Hercules, in the west, across the head of Serpens, the lower limbs of Bootes, the shoulder of Virgo, Coma Berenices, the limbs of Leo Major and Cancer to the lower limbs of Gemini. 2 p. m., continuation in about the same northern position as a bright golden curtain; bow delicately tinted reddish green. 5 p. m., continuation. 7:45 p. m., a very beautiful double curtain arch (or arches) extending from Sextans and the paws of Leo Major (in the east-northeast) across Cancer, the lower limbs of Gemini, Auriga, Taurus, Aries, and Cetus, with very bright arcs upon the chest of Orion. Entire display lavishly tinted in red, green, and purple. Remarkable motion in the double arch, the upper or more northern bow waving rapidly from west to east, the other curtain undulating as hurriedly from east to west. Wind blowing about 20 miles per hour from the north. Bright moonlight (new half moon in south-southwest). No clouds visible. Arches appear to have unusually low altitudes, referred to the surface of the earth. Pressure, 30.12; temperature, —28.0° F.; wind, northeast at 18 miles per hour.

January 20, 1899, 3 *to* 5 *p. m.*—Aurora, began at 3 p. m. as a double arch or golden bow, becoming a wide band extending from Auriga, in the east, across the fore limbs of Camelopardus, Lynx, the tail of Draco, the head, rump, and tail of Ursa Major and Ursa Minor to Bootes and Hercules. At the beginning of the display the western end of the bow was crossed (subtended) by bands of stratus clouds, the eastern extremity being submerged in a misty appearance of atmosphere. 5 p. m., faint auroral arcs (quite buried in a shower of minute snow crystals) covering the constellations of the celestial ecliptic (stars invisible, but the position of ecliptic known). Pressure, 29.85; temperature, —29.5° to —26.0° F.; wind, south, light.

January 21, 1899, 4 *to* 6:45 *p. m.*—Aurora, began at 4 p. m. as a series of bright red-green tinted golden curtain arcs from Auriga and Gemini, in the east, across Lynx and Ursa Major to Bootes, in the northwest. Invisible at 5 p. m. 6:45 p. m., phenomenon of indescribable beauty, the arctic night displaying a magnificent furnishing of vari-colored cloths of gold and silks of silver, now in tumbling arcs or trembling bows, in hanging curtains or waving tapestry, and then in dancing beams or ascending rods of gold, in swirling pots of color or quiescent seas of silver, all swinging from the sparkling stars, from Polaris to the bright moon-bearing Taurus, in the south, to Corona Borealis and Bootes, in the north, to Leo Major and Cancer, in the east, and to Aquila, in the west, deigning even to cast a resplendent arc to the snow-clad earth itself, resting it upon the basaltic sentinel of Tegetthoff.

About 200 yards northwest of the observatory stands a bold basaltic spire about 400 feet in height. A bright spot of this display appeared to descend below the summit of the spire, dimming its upper outline, the intense portion of the display intervening between the observer and the spire.

Pressure, 30.01 to 30.05; temperature, —31.0° to —33.0° F.; wind, west, light.

January 22, 1899, 3:30 *to* 5 *p. m.*—Aurora, 3:30 p. m., greenish gauze-like arches, extending from Leo Major, in the northeast, across Cancer, Gemini, head of Orion, horns of Taurus, Auriga, Lynx, Camelopardus, Ursa Major, Ursa Minor, Cepheus, Cassiopeia, Cygnus, Lyra, Hercules, Aquila, and Ophiuchus. 5 p. m., in nearly the same position; more intense. Pressure, 30.18 to 30.15; temperature, —34.0° F.; wind, northeast at 7 miles per hour.

January 23, 1899, 9 *a. m.*—Aurora, very light beams ascending across Leo Major, in the west. Pressure, 30.14; temperature, —33.0° F.; wind, southwest at 7 miles per hour.

January 24, 1899, 5 *p. m.*—Aurora, a bright golden curtain above alto-stratus clouds in the northeast, crossing Leo Major and Lynx. Pressure, 30.25; temperature, —12.5; wind, north, light.

January 27, 1899, 5 *p. m.*—Aurora, a curtain arch from Auriga, in the southeast, across the rump of Camelopardus, Cassiopeia, Cepheus, Cygnus, Lyra, Hercules, and Corona Borealis, in the west; brightest in its western termination and tinted reddish-green. Pressure, 30.08; temperature, —27.0° F.; wind, northeast, at 26 miles per hour. Bright lunar halo in the northeast.

January 29, 1898, 5 *to* 8 *p. m.*—Aurora, a golden bow from Canis Minor, in the east-northeast, across the head and shoulders of Orion, Taurus, Aries, Pegasus, and Delphinus, to Aquila; western portion above alto-stratus clouds. 8 p. m., continuation of the display above stratus clouds in the east, southeast, south, southwest, and west. Pressure, 30.24 to 30.20; temperature, —26.0 F.; wind, north at 28 miles per hour.

January 30, 1899, 5 *to* 8:30 *p. m.*—Aurora, light beams ascending from Gemini and Auriga, in the northeast and east, and from Aquila, in the west. 8 p. m., a golden arc crossing Canis Minor, Orion, Taurus, and Cetus. 8:30 p. m., bright double curtain arches extending from Leo Major, in the northeast, and crossing Cancer, Gemini, Auriga, Andromeda, and Pegasus, the more southern bow being bright golden, the other of dark lilac color. Display subtended in places by lower stratus clouds. Pressure, 30.05; temperature, —35.0° F. to —39.0° F.; wind, northeast at 13.5 miles per hour.

January 31, 1898, 5 *to* 10 *p. m.*—Aurora, a golden arc extending above stratus cloud bands, from Canis Minor, in the east, across the head of Orion, Taurus, Aries, Andromeda, Cygnus, and Vulpecula, in the southwest. 10 p. m., continuation somewhat higher in the heavens. Pressure, 30.00; temperature, —43.0° to —45.0° F.; wind, northeast at 19.5 miles per hour.

February 1, 1899, 5 *p. m.*—Aurora, a golden arc crossing

Canis Minor, in the east, the head and shoulders of Orion, Taurus, Aries, Pegasus, and Aquila. Pressure, 29.89; temperature, —38.0° F.; wind, northeast at 20 miles per hour.

February 2, 1899, 5 *p. m.*—Aurora, light beams ascending from Canis Minor, in the east-northeast, crossing Gemini, and continuing thence as a light gold wire band across Lynx, Ursa Major, the tail of Draco, Ursa Minor, the body of Draco, Cepheus, Cygnus, and Lyra to Aquila. Pressure, 29.84; temperature, —41.0° F.; wind, north at 27 miles per hour.

February, 5, 1899, 3 *p. m.*—Aurora, springing from Leo Major, (in the east), and crossing Leo Minor, the forepaws and head of Ursa Major, Lynx, Camelopardus, Cassiopeia, and Cygnus. Pressure, 29.78; temperature, —11.5 F.; wind, east at 26.2 miles per hour.

February 8, 1899, 7 *p. m.*—Aurora, a golden arch springing from Leo Major, in the east-northeast, crossing the forepaws and head of Ursa Major, Lynx, Camelopardus, Cassiopeia, Cepheus, and Lacerta, the lower wing of Cygnus and Vulpecula, and terminating upon Aquila, in the west. Pressure, 29.25; temperature, —22.0° F.; wind, north, light.

February 9, 1899, 5 *p. m.*—Aurora, a light streamer arch from Leo Major, in the east, and crossing the constellations, thence through the zenith westward. Pressure, 29.64; temperature, —32.5 F.; wind, southwest, very light.

February 15, 1899, 4 *to* 7 *p. m.*—Aurora, plainly visible in the east and south at 4 p. m., but veiled by fog. Stars invisible. 7 p. m., bright golden arcs and arches extending from Leo Major, in the east, across Cancer, Gemini, Auriga, Taurus, Aries, Pegasus, etc., westward to Aquila. Display invisible by reason of fog or heavy mist at times. Pressure, 30.20 to 30.22; temperature, —6.0° to —10.0° F.; wind, north at 9.5 miles per hour.

February 16, 1899, 8 *p. m.*—Aurora, very active display of yellow arcs and patches covering the heavens from the eastern to the western horizon for a space of about 90° in width and visible through a murky sky and light fall of snow. Occasionally stars visible. Pressure, 30.18; temperature, —6.0° F.; wind, north, light.

February 23, 1899, 9 *p. m.*—Aurora, golden arcs extending from the feet of Bootes in the east-northeast across Leo Major, Cancer, the feet of Gemini, and the belt of Orion to Cetus in the southwest. Wave like motion from west to east. Pressure, 30 17; temperature, —30.7° F.; wind, northeast, light.

March 2, 1899, 8 *p. m.*—Aurora, a faint silvery arc springing from Leo Major (in the east-southeast), and crossing Leo Minor, Lynx, and Camelopardus, to the feet of Cassiopeia. Pressure, 30.35; temperature, —35° F.; wind, north at 10 miles per hour.

March 3, 1899, 8 *p. m.*—Aurora, an intense display of coronal type, covering the heavens from the belt of Orion in the south-southwest to the lower limbs of Hercules in the north, and from Virgo in the east to Pegasus and Pisces in the west. Rapid movement of streamers and curtains from west to east and from south to north. Delicate tinting of the display in all its parts, but particularly striking along the edges of the enveloping or outer curtains. Central or zenithal portion less tenuous than the parts nearer the horizon. Pressure, 30.30; temperature, —41° F.; wind, north, light.

March 10, 1899, 11 *p. m.*—Aurora, the heavens from the feet of Bootes in the east to the head of Cetus in the west; from the paws of Leo Major in the south to Pegasus in the north, curtained, festooned, tapestried, arched, and pillared in gold and silver, in purple and lilac, and red-green, all waving, trembling, tumbling, and leaping in every imaginable direction. And yet, why, at the same time, that motionless shaft upon the head of Taurus or that quiescent arc amidst a vortex of motion? Pressure, 29.75; temperature, —32.0° F.; wind, west, very light.

March 11, 1899, 9:45 *p. m.*—Aurora, yellowish bands, extending from east to west across the space between the back of Leo Major, in the south, and Polaris. The sky much clouded and a minute description of the display impossible. Pressure, 29.95; temperature, —24.0° F.; wind, north, light.

March 13, 1899, 11 *p. m. to* 12 *midnight.*—Aurora, pink-tinted arcs and dancing shafts upon Gemini and Auriga, in the southwest. 12 midnight, golden haze upon Leo Minor. Pressure, 30.28; temperature, —33.0° to 33.0° F.; wind, north, light.

MEXICAN CLIMATOLOGICAL DATA.

Through the kind cooperation of Señor Manuel E. Pastrana, Director of the Central Meteorologic-Magnetic Observatory, the monthly summaries of Mexican data are now communicated in manuscript, in advance of their publication in the Boletin Mensual. An abstract, translated into English measures, is here given, in continuation of the similar tables published in the MONTHLY WEATHER REVIEW since 1896. The barometric means have not been reduced to standard gravity, but this correction will be given at some future date when the pressures are published in our Chart IV.

Mexican data for March, 1901.

Stations.	Altitude.	Mean barometer.	Temperature.			Relative humidity.	Precipitation.	Prevailing direction.	
			Max.	Min.	Mean.			Wind.	Cloud.
	Feet.	*Inch.*	° *F.*	° *F.*	° *F.*	%	*Inch.*		
Durango (Seminario).	6,243	24.02	88.2	35.6	59.4	38	.....	sw.	w.
Leon (Guanajuato)...	5,934	24.30	85.5	34.0	63.0	37	.....	nw.	sw.
Linares (Nuevo Leon).	1,188	28.64	101.3	42.8	70 5	51	T.	s.	s , w.
Mazatlan	25	29.95	80.8	63.9	72.1	76	....	nw.	sw.
Merida	50	29.98	92.8	57.0	75.6	68	0.08	ne.	.....
Mexico (Obs. Cent.)..	7,472	23.06	84.2	35.6	60.6	37	0.01	sw.	....
Morelia (Seminario)..	6,401	23.96	83.0	41.4	59.9	47	0.03	s.	w.
Puebla (Col. Cat.)...	7,112	23.39	82.4	38.3	62.6	42	T.	e.	ssw.
Saltillo (Col. S. Juan).	5,399	24.75	86.0	32.0	61.7	69	.....	s.	s.
San Luis Potosi.....	6,201	24.10	86.2	39.6	62.8	54	.....	sw.	w.
Zapotlan (Seminario)	5,078	25.10	90.7	39.2	64.4	39	0.03	sse.	w.

RECENT PAPERS BEARING ON METEOROLOGY.

W. F. R. PHILLIPS, in charge of Library, etc.

The subjoined list of titles has been selected from the contents of the periodicals and serials recently received in the library of the Weather Bureau. The titles selected are of papers or other communications bearing on meteorology or cognate branches of science. This is not a complete index of the meteorological contents of all the journals from which it has been compiled; it shows only the articles that appear to the compiler likely to be of particular interest in connection with the work of the Weather Bureau:

Comptes Rendus. Paris. Tome 132.

Angot, A. Sur la variation diurne de la déclinaison magnétique. P. 317.

Symons's Meteorological Magazine. London. Vol. 36.

Curtis, R. H. Pressure of the Wind. P. 2.

Gaea. Leipzig. 37 *Jahrg.*

Elster, J. und Geitel, H. Beiträge zur Kenntnis der atmosphärischen Elektricität. P. 142.

Wollny, E. Ueber den Einfluss der Pflanzendecken auf die Wasserführung der Flusse. P. 162.

Memorias y Revista, Sociedad Cientifica "Antonio Alzate." Mexico. Tomo 15.

Morena y Anda. Correcciones que deben aplicarse á la media diurna de la temperatura deducida de pocas observaciones. Pp. 5–11.

Geographische Zeitschrift. Leipzig. 7 *Jahrg.*

Hann, J. Wissenschaftliche Luftfahrten. Pp. 121–140.

Nature. London. Vol. 63.

Judd, J. W. Recent "Blood Rains." Pp. 514–515.

Bryan, G. H. History and Progress of Aerial Locomotion. Pp. 526–527.

Hayward, R. B. Audibility of the Sound of Firing on February 1. Pp. 538–540.

Buchanan, J. Y. Solar Calorimeter depending on the rate of generation of Steam. Pp. 548–551.